

How does fire kill trees?

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Fires burn millions of acres annually and being able to predict what trees will die after fire is important for forest management.

Fire-caused tree mortality depends on what happens before, during, and after fire.

Pre-fire – Drought and competition can increase vulnerability to fire through increased plant-stress and by influencing the physical fire environment and increasing fire intensity.

During fire – Injuries occur to different parts of trees through heat transfer processes such as convection, conduction and radiation, and direct tree death from fire is via heat injuries to crown, bole, and root tissues. Crown scorch reduces capacity for photosynthesis and requires stored carbon reserves to rebuild leaves. Bark thickness is an important factor of resistance because it protects the tree's main stem from heating.

Post-fire – Some trees are killed immediately by fire but others die up to several years later. Fire-injured trees are more susceptible to other stressors, such as beetle attack and drought. Trees with adaptive traits—protective buds or ability to re-sprout—can recover more easily post-fire.

The combination of fire injuries with other factors like drought, competition, and bark beetles is used to develop models that predict which trees will die after fire. These models are used in fine-scale software tools for prescribed fire and wildfire planning, landscape succession models, and earth system models of the terrestrial carbon cycle.

Photo: Heat is transferred to living tissues of trees during fire (top panel), resulting in injuries to different parts of trees after fire (bottom panel). Fire causes injuries to different parts of trees—buds, foliage, cambium in the stem, and roots—through three different heat transfer processes. Combustion directly consumes live foliage and buds, small live branches, and small trees and causes tissue death. Convection, the movement of hot air—and radiation, heat traveling as energy waves, causes tissue death when temperatures are $\geq 60^\circ\text{C}$ for 1 s. Bole heating: Heat is conducted through the bark of trees, but because bark is a poor conductor it insulates the live cambium underneath from heat. Thick bark insulates larger trees of some species, while thin bark provides little insulation on smaller trees and thin-barked species. Soil and root heating primarily occurs through conduction during smoldering combustion of duff and large logs. Graphics by R Van Pelt.

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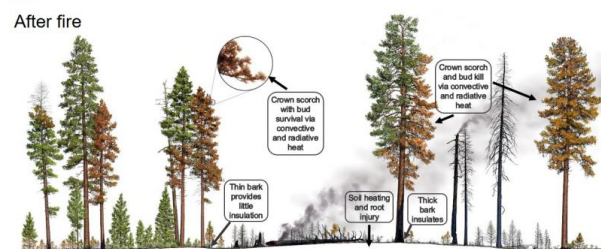
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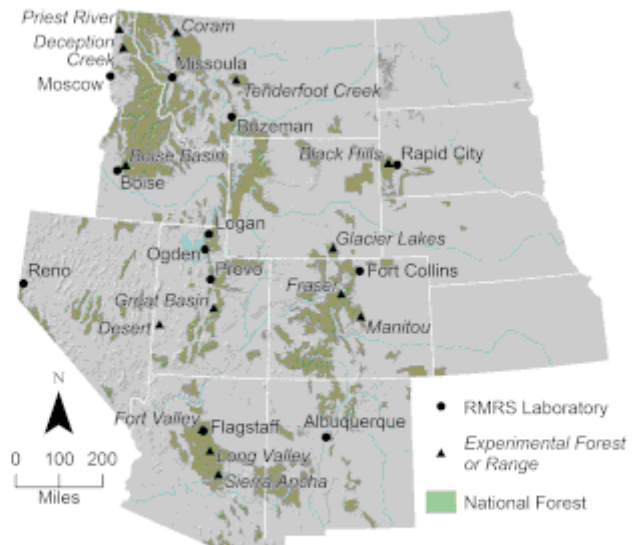
During and after fire

- This review:

- Describes the current understanding of the mechanisms of fire-induced tree mortality
- Provides recommended standardized terminology
- Describes model applications and limitations
- Identifies key knowledge gaps and future directions for research.

About the Rocky Mountain Research Station

The Rocky Mountain Research Station is one of seven units within the USDA Forest Service Research & Development. RMRS maintains 14 field laboratories throughout a 12-state territory encompassing parts of the Great Basin, Southwest, Rocky Mountains, and the Great Plains. While anchored in the geography of the West, our research is global in scale. RMRS also administers and conducts research on 14 experimental forests and ranges and maintains long-term research databases for these areas. Our mission is to develop and deliver scientific knowledge and innovative technology to improve the health and use of forests and rangelands – both public and private. RMRS science improves lives & landscapes.



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